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Session 3B: Pollutant Removal

Kentucky Water Resources Research Institute, University of Kentucky

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Investigation of PlarClean and Gamma-Valerolactone as Solvents for Polysulfone Membrane Fabrication

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Petroleum-derived solvents used for membrane fabrication through the nonsolvent induced phase separation (NIPS) process are known for their toxicity. Therefore, bio-derived and low-toxicity solvents are starting to be investigated. Examples of bio-derived, low-toxicity solvents include methyl-5- (dimethylamino)-2-methyl-5-oxopentanoate (PolarClean) and gamma-valerolactone (GVL). PolarClean has been previously used to fabricate polysulfone (PSf) membranes with mixed results, such as having similar flux and rejection as traditional membranes, but having membrane pores collapse during membrane cleaning. To address this issue, GVL was investigated as a sole solvent and a co-solvent with PolarClean to fabricate PSf membranes. Membranes prepared using GVL as a sole solvent were observed to be gelatinous, hence not ideal for filtration. On the other hand, when GVL and PolarClean were used as co-solvents, viable membranes were cast with surface charge and hydrophicility not being significantly different from membranes made using PolarClean alone. Furthermore, the average pore size of membranes decreased as the weight percent of GVL in dope solutions increased. Therefore, the use of PolarClean/GVL as co-solvents shows promise for the fabrication of PSf membranes.

Selenium Removal Using Bacteria Entrapped Alginate Gel Beads in a Packed-Bed Reactor

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Selenium has become one of the concerning pollutant in recent years. Its concentration was regulated as 3.1 μg/L in lotic fresh water and 2 μg/L for lentic fresh water by EPA. Selenium has four different oxidation states including Se(VI), Se(IV), Se(0) and Se(-II) with two dominant soluble species in water including Se(VI) and selenite. Anthropogenic activities including glass and pigments manufacturing, fossil fuel combustion, irrigation, mining and metal refining are responsible for most of selenium release into environment. Although selenium is an essential micronutrient, its toxicity may occur at supra-nutritional dosage with symptoms of nausea, vomiting, nail discoloration, brittleness, hair loss, fatigue and irritability. Selenium toxicity on aquatic lives was also reported and can cause reproductive failure, mortality as well as deformities. Traditional treatment technologies of selenium include ion exchange, reverse osmosis, zero-valent ion, adsorption and microbial reduction with few effective in both Se(VI) and Se(IV) removal. Biological selenium reduction provides an alternative in selenium removal. However, as an anaerobic process, active cell loss is significant without immobilization.

In this study, cells of a Se(VI)-reducing strain *Shigella fergusonii* were immobilized in alginate gel beads and packed in continuous-flow reactor. Se(VI) was fed at 10, 50, 200 and 400 mg/L, respectively, with a total duration of 96 days. An HRT of 5.5 days was performed. The results show that the steady states were achieved at all feeding concentrations. 95% Se(VI) was removal with Se(VI) fed at 400 mg/L from the reactor with little Se(IV) detected, indicating the process was both effective in Se(VI) and Se(IV) removal. The results also show that more than 70% of Se(VI) was removed in the reactor under a height of 5.2 cm.

Nanotechnology and Membranes: Water detoxification from Lab Scale to Real Site Applications

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The detoxification of toxic chlorinated organics (trichloroethylene, polychlorinated biphenyls) in groundwater has been widely studied using zero-valent iron (ZVI) and ZVI based bimetallic nanoparticles. To apply the nano-scale particles in field treatment, the functionalized poly(methacrylic acid) membrane platform was used to immobilize nanoparticles and prevent aggregation and leaching of metal particles. The membrane system showed great performance on the treatment of lab synergic polychlorinated biphenyls and field water samples (from a Superfund site, which includes trichloroethylene, tetrachloroethylene, chloroform and carbon tetrachloride). At 2.2 seconds of residence time, nearly 80% of target chlorinated organic species (in ppm level) in the field samples were dechlorinated.

Advanced characterization methods, such as FIB, TEM and XPS, were applied to study the correlation between nanoparticle properties and depth inside membrane pores, leading to the optimization of membrane design and treatment performance. Particles size (17.1 ± 4.9 nm) and density were observed as a uniform distribution inside the membrane matrix.

In addition, fundamental studies on water conditions, such as pH, temperature and hardness, as well as bimetallic particle aspects were made to optimize the dechlorination performance and cost of materials. Even though Pd served as a catalyst in the dechlorination, excess Pd could decrease the available Fe surface for water corrosion, which leads to the deficiency of H_2 production and eventually decreases the dechlorination rate. The 0.5 wt% Pd (as Fe) showed both high reactivity and low cost.

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